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Long-term future projections for the Antarctic ice sheet with the model SICOPOLIS

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As part of the Coupled Model Intercomparison Project Phase 6 (CMIP6) (Eyring et al. 2016) the Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) was devised to assess the likely sea-level-rise contribution from the Greenland and Antarctic ice sheets until the year 2100 (Nowicki et al. 2020). ISMIP6 used future climate scenarios as forcings for ice sheet models developed by different international groups. Results obtained with the model SICOPOLIS for the Antarctic ice sheet are summarized in Greve et al. (2020).

We use the model SICOPOLIS to carry out extended versions of the ISMIP6 future climate experiments for the Antarctic ice sheet (AIS) until the year 3000. The ISMIP6 projections run from the beginning of 2015 until the end of 2100, and then for the atmospheric forcing (anomalies of surface mass balance and temperature) beyond 2100, we randomly sample the ten-year interval 2091–2100 such that no further warming trend is applied, as shown schematically on Figure 1. Fourteen experiments are for the pessimistic, "business as usual" pathway RCP8.5 (CMIP5) / SSP5-8.5 (CMIP6), and three are for the optimistic RCP2.6 (CMIP5) / SSP1-2.6 (CMIP6) pathway that represents substantial emissions reductions. For the RCP8.5/SSP5-8.5 simulations, a large difference in the vulnerability of east and west Antarctica develops over hundreds of years with west Antarctica suffering a much more severe ice loss as shown in Figure 2. In these cases, the AIS suffers a mass loss, which amounts to an average across the simulations of ~3.3 m sea-level contribution as indicated in Figure 3. For RCP2.6/SSP1-2.6, the mass loss is limited to a three-experiment mean of ~0.25 m sea-level contribution. The simulations produce a result where mitigation through the remainder of the 21st century saves the west Antarctic Ice Sheet in the long term.

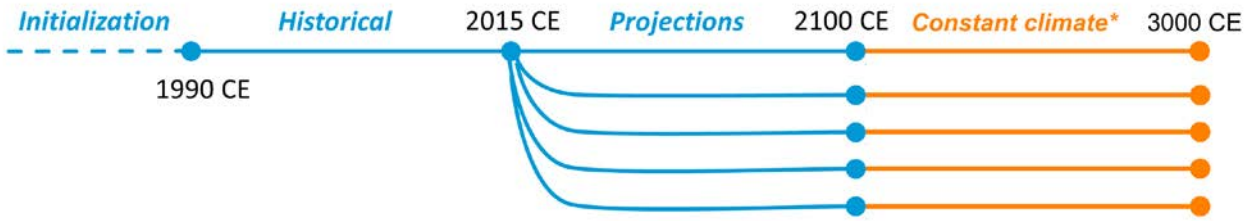

Figure 1. ISMIP6 experimental design. A model-specific initialization is followed by a historical simulation from 1990 until 2015. The several projections run from 2015 until the end of 2100. *Beyond 2100, the simulations continue under a constant climate created by randomly sample the ten-year interval 2091–2100. (Credit: edit of Figure 1 in Greve et al. 2020 by Martin Rückamp, AWI Bremerhaven, Germany.)

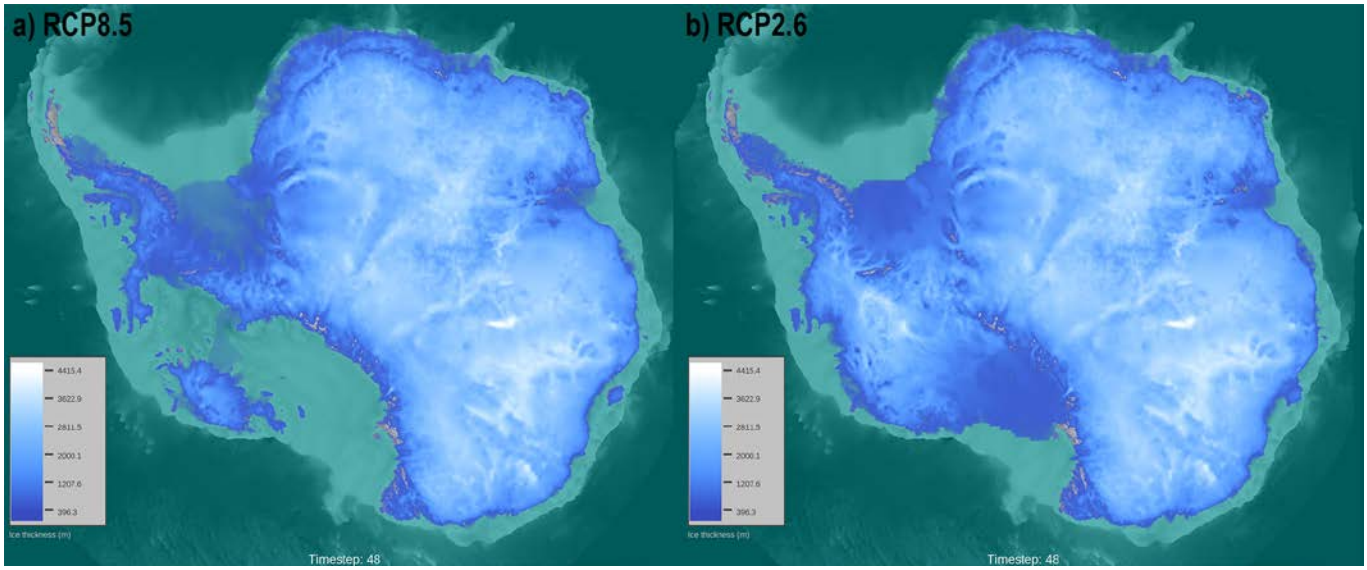

Figure 2. Ice thickness (m) for the end of two simulations (year 3000) that both use the NorESM1-M AOGCM for a) business as usual scenario (RCP8.5) and b) optimistic mitigation scenario (RCP2.6).

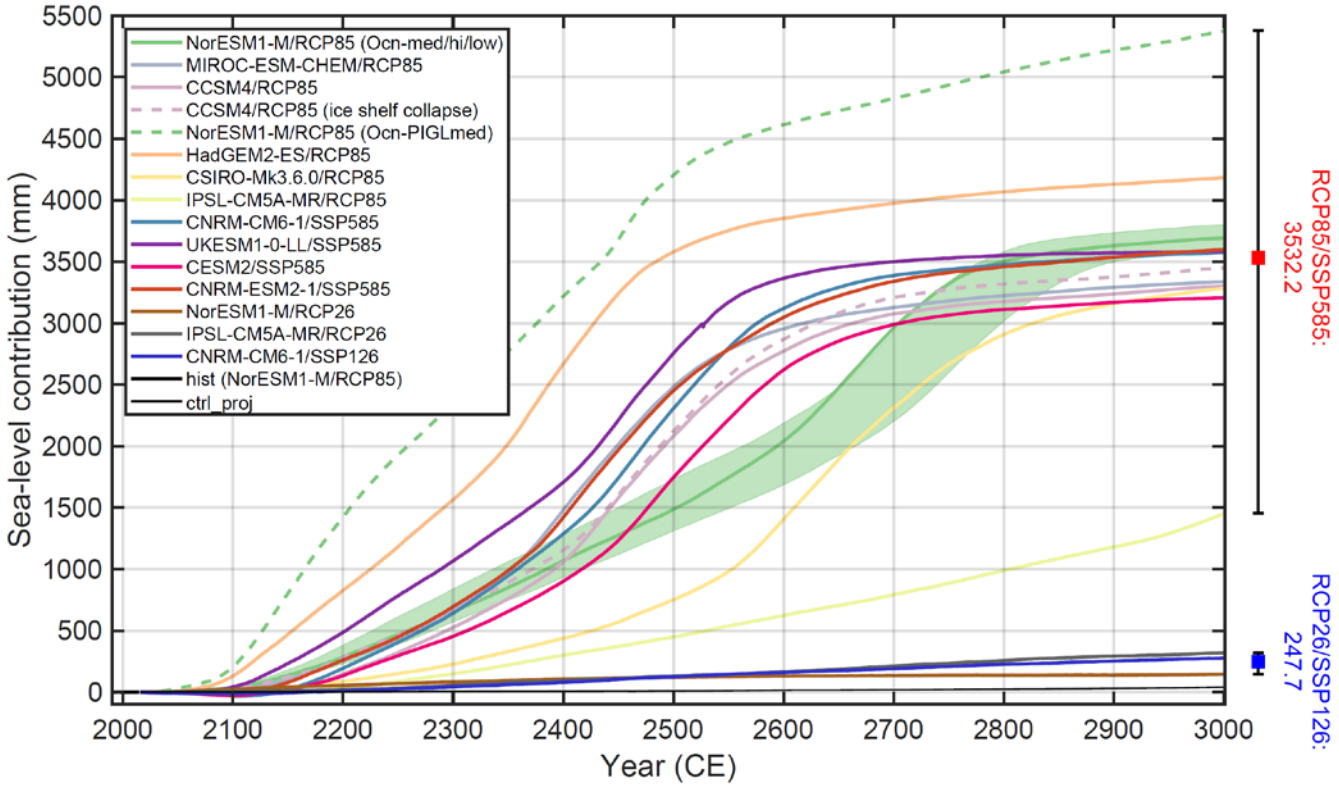

Figure 3. Extended ISMIP6 future climate experiments simulated ice mass change, counted positively for loss and expressed as sea-level contribution.

References

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